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ABSTRACT

The purpose of this study was to longitudinally examine the development of anticipatory visual search and to find out the effects of preceding experiences upon the search during the second year of life. The sample consisted of 18 Japanese firstborn nonretarded children from middle-class families who were individually tested at 11, 12, 14, 16, 22, and 24 months. At each test session, each subject received 2 trials at a task in which an object disappeared at a tunnel entrance and reappeared at an exit. The child's visual fixation toward the object and the entrance, the exit, and other zones of the tunnel was measured and the entire procedure was videotaped. Visual search during occlusion of the object was assigned to five levels of anticipation. Findings indicated a developmental sequence from level I to level III and a transition period of 14 months. Within level III, change occurred from level III-1 to level III-3 across a period of 22 months. Level II and level III-2 were regarded as transitional levels despite their limted emergence due to the decrement of their occurrence at later months. Such development was interpreted as the reflection of the process of coordination between spatial and temporal information in object permanence. (RH)

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DEVELOPMENT OF ANTICIPATORY VISUAL SEARCH IN ONE-YEAR-OLDS

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The onset of expectancy or anticipation was found in newborn infants by the studies on classical conditioning of heart rate (Clifton, 1974; Stamps & Porges, 1975). The neonates showed heart rate deceleration in the absence of unconditioned stimuli. In operant conditioning, 3-month-olds demonstrated not only the acquisition of expectancy about quantitative aspects of their reinforcing stimuli (Fagan & Rovee, 1976), but also generalized expectancy of their reinforcing stimuli (Fagan et al., 1984).

However, the onset of anticipation has been controversial in the studies of object permanence which usually did not include intentional conditioning whereas infants were provided with several trials for the same task. Bower and his colleagues (1971, 1973, 1974), and Simoneau & Decarie (1979) revealed 5-month-olds' anticipation in visual tracking tasks. Moore et al. (1978) regarded 5-month-olds' anticipation as the reflection of object identity rather than object permanence which appeared at 9 months of age in their study.

As opposed to the studies mentioned above, several studies could not find anticipatory visual search in 5-month-olds. Goldberg (1976) reported no evidence of 5-month-olds' expectancy that a stable object continue to exist behind a screen. In the study by Nelson (1971), both 5- and 8-month-olds continued to look at the entrance of a tunnel where a model train disappeared on the first 4 trials when the train reappeared from the opposite side of the tunnel. Over 7-10 trials, looking at other zones of the tunnel prior to the train's reemergence decreased and anticipatory visual fixation to the tunnel exit increased until 25%. Their tunnel and

anticipation scores did not differ for the 2 age groups but for the number of criterion trials where the infants showed visual movement towards the tunnel exit before the train's reappearance. Meicler & Gratch (1980) did not find anticipatory visual search in 5-month-olds but in 9-month-olds. However, the mean anticipation scores of the 9-month-olds' trials implied that they looked at the screen exit but look back to the screen entrance and did not see a toy reemerge. Over trials, 65% of the 9-month-olds gained the highest score on at least one trial, i.e., looked to the exit immediately after the toy disappeared and waited for it to reappear, as opposed to 35% showing no evidence of anticipation.

Since infants in previous studies on object permanence were given several trials for the same task in a session, even 9-month-olds' anticipatory visual search is interpreted to stem from their experiences immediately before. For Piaget (1937/1954), object permanence was attained at the stage 6 of sensorimotor intelligence. The infants of stage 6 would demonstrate definite anticipatory behavior on the first trial rather than after several trials. In addition, the immediately preceding experience would affect a subsequent trial in a different manner in the course of development. Therefore, the purpose of this study was to longitudinally examine the development of anticipatory visual search and to find out the effects of preceding experiences upon the search during the second year of life.

METHOD

1. Subjects

The samples were 18 Japanese firstborn nonretarded children (9 males, 9 females) from middle-class families. They were selected from the files of the Well Babies Clinic* at Kosei Hospital in Tokyo where their neurological, physical and psychological development had been examined regularly. Their cognitive and language development had been followed experimentally in this institute since the age of 6 months. Thirteen out

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* The clinic was closed after this study.

of 18 children (72%) had already passed the task of manually searching a hidden object at 3-hide-positions, which implied the stage 5 of sensori-motor intelligence (Piaget, 1937/1954), when this study began.

2. Apparatus

A 50-cm-long and 15-cm-high tunnel was placed in the center of a 100-cm-long track with a front wall which hid a flat carrier and a fine transparent wire attached to the carrier. The tunnel, track and wall were made of white cardboard. An object was mounted on the carrier. The above apparatus was set on a table. An experimenter pulled the wire under the table so that visible movement of the object prior to disappearance and after reappearance lasted 3 sec each and the object was occluded for 6 sec. Several small colored toys were selected as the hidden objects.

3. Procedure

The experiments were conducted in a small carpeted room at this institute without any equipment except for air-conditioning. The room was divided into 2 parts by a screen for observing and videotape recording. The children were individually tested at the rate of one session per month at 11, 12, 14, 16, 22 and 24 months of age. The child was seated at the midline of the table without a reaching distance from the apparatus. The child's mother sat behind the child. The experimenter selected one of the objects under the table and mounted it on the carrier placed at one end of the track. The experimenter pointed to the object telling to the child "Look!". After confirming the child's visual fixation to the object, the experimenter pulled the wire attached to the carrier under the table so that the object moved toward the other end of the track. The child could not see the experimenter select the object or operate the movement of the object due to the board under the table. After leaving the object at the other end of the track for 3 sec, the experimenter gave it to the child to play with for a while regardless the child's behavior during the occlusion of the object. Each session was composed of 2 trials and the direction of movement remained the same on the 2 trials while it was counterbalanced across sessions.

4. Recording and Data Reduction

Immediately after the child's visual fixation to the object placed at

one end of the track, 2 trained observers measured independently with electric event recorders the child's visual fixation time to either the object, the entrance, the exit or other zones of the tunnel as well as marking the onset of movement, the disappearance, the reappearance and the end of movement of the object, and the time when the experimenter picked up the object from the carrier. The whole session was videotaped. The tape was copied and 1/10 sec time intervals were marked off.

The 2 observers cooperated to describe the child's visual search with a given form based on the records of fixation time and copied videotape recording. The visual search during the occlusion of the object was assigned to 5 levels of anticipation, level I, level II, level III-1, level III-2 and level III-3. The definitions of levels of anticipatory visual search are shown in Table 1.

RESULTS

1. Development of Anticipatory Visual Search

1) Level I, level II and level III on trial 1

(1) sequential onset of 3 levels

All children kept visual fixation to the object until its disappearance and then looked at the tunnel entrance for one sec or more across sessions. The onset of 3 levels on trial 1 was as follows.

level I $\bar{X} = 11.2$, SD = 0.7; Mdn = 11, R = 11 - 14

level II $\bar{X} = 13.3$, SD = 1.8; Mdn = 14, R = 11 - 16

level III $\bar{X} = 16.1$, SD = 3.9; Mdn = 16, R = 11 - 24

The 22% children showing level III on trial 1 of 14 or earlier months tended to demonstrate lower levels at consecutive months, while they had already passed the manual search task at 3-hide-positions by 11 months. On the other hand, the level III initiated on trial 1 of 16 or later months was stable not only on trial 1 but also trial 2 of subsequent months. Neither the onset of level III on trial 1 nor on both trials was correlated with the onset of passing the above manual search task whereas all children passed it by 13 months.

In terms of sequential onset of levels, 44% children revealed the

sequence of level I → II → III, 50% for that of level I → II and 44% for that of level II → III. Neither of these values was significant (binomial test). Yet the sequence of level I → III showed significance (94% children, $P = .0001$, binomial test). These results are probably because nonoccurrence of level II and the reversal sequence of level II → I were seen in 33% and 11% children, respectively.

(2) percent of children showing each level

As seen in Fig. 1, 83% children demonstrated level I at 11 months. At 12 months, the percent of children showing level I decreased and that of level III increased (McNemar test, $df = 1$, one-tailed; $\chi^2 = 3.57$, $P < .05$; $\chi^2 = 3$, $P < .05$). Level I still tended to dominate over level II and level III ($\chi^2 = 4.01$, $df = 2$, $.1 > P > .05$, one-tailed). At 14 months, the percent of children was similar in level I and level III. At 16 months, the percent of children showing level I decreased and that of level III increased ($\chi^2 = 6$, $P < .01$; $\chi^2 = 4.5$, $P < .025$). Seventy-two percent children showed level III and were superior to those of level I and level II ($\chi^2 = 12.33$, $df = 2$, $P < .0025$). At 22 months, the percent of children showing level II tended to decrease and that of level III increased ($\chi^2 = 2$, $.1 > P > .05$; $\chi^2 = 3$, $P < .05$). Level III was observed in 89% children. All children exhibited level III at 24 months.

In sum, the developmental change from level I to level III and 14 months as a transition period were confirmed. While level II did not dominate during a period of 11-24 months, it tended to decrease at 22 months and was not seen at 24 months. Among different patterns of level II, looking at the tunnel entrance on the occasion of the reappearance of the object was observed in 54% instances as opposed to 31% for other zones of the tunnel. Such visual fixation to the entrance significantly more occurred than to other zones of the tunnel in level I (61% instances; $\chi^2 = 5$, $df = 1$, $P < .025$, one-tailed).

2) Sublevels of level III on trial 1

(1) sequential onset of 3 sublevels

Not all children exhibited each of 3 sublevels: 67% for level III-1, 67% for level III-2 and 72% for level III-3. The onset of 3 sublevels on trial 1 was as follows:

level III-1 $\bar{X} = 15.3$, SD = 0.9; Mdn = 16, R = 14-16

level III-2 $\bar{X} = 19.6$, SD = 4.6; Mdn = 22, R = 11-24

level III-3 $\bar{X} = 20.0$, SD = 4.7; Mdn = 22, R = 12-24

Only 22% children demonstrated 3 sublevels. The sequential onset of level III-1 → level III-2 → level III-3 was seen in 50% of those children (11% of all children). The percent of children showing 2 sublevels of either combination was from 44 to 50. The sequence of level III-1 → level III-3 was most often demonstrated (39% of all children).

(2) percent of children showing each sublevel

As seen in Fig. 2, 5% children showed level III-2 at 11 months. At 12 months, level III-2 and level III-3 were seen in 11% children each. At 14 months, the percent of children showing level III-1 increased (McNemar test, df = 1, one-tailed; $\chi^2 = 4$, $P < .025$). At 16 months, the percent of children showing level III-1 increased ($\chi^2 = 5.44$, $P < .01$) and level III-1 dominated over level III-2 and level III-3 ($\chi^2 = 14.5$, df = 2, $P < .001$, one-tailed). At 22 months, the percent of children showing level III-1 decreased ($\chi^2 = 4.5$, $P < .025$) and those of level III-2 and level III-3 increased ($\chi^2 = 5$, $P < .025$; $\chi^2 = 4$, $P < .025$). Each sublevel was seen in about one third children. At 24 months, the percent of children showing level III-3 increased ($\chi^2 = 6$, $P < .01$). Level III-3 was superior and exhibited by 61% children ($\chi^2 = 6.32$, df = 2, $P < .025$, one-tailed).

In sum, the developmental sequence from level III-1 to level III-3 and 22 months as a transition period were clear. While level III-2 did not dominate during a period of 11-24 months, it showed marked increment at 22 months.

Looking back to the tunnel entrance was still dominant in level III-1 (83% instances) whereas the children showing level III-1 saw the object reappear in time. Fifty-six percent of children showing either level III-1 or level III-2 exhibited eye movement towards the tunnel as if to follow the invisible movement of the object. Looking at the experimenter during the occlusion of the object was observed in 89% children and the onset of such behavior was at 11 or 12 months. However, the onset of smiling or laughing the experimenter after the object's reemergence was 16 months of the median age of 83% children. The initial occurrence of

such behavior during the occlusion of the object was seen at 24 months of the median age of 56% children.

2. Comparison of Anticipatory Visual Search between Two Trials

The differences of level I, level II or level III between 2 trials were seen in Fig. 3. The statistical significance was found in level I of 12 months and in level III of 16 months (McNemar test, df = 1, one-tailed; $\chi^2 = 6.4$, $P < .01$; $\chi^2 = 3$, $P < .05$). The percent of children showing level I decreased on trial 2 of 12 months and that of level III increased on trial 2 of 16 months.

The changes of each sublevel of level III between 2 trials were shown in Fig. 4. The differences in level III-1 of 12 months, in level III-3 of 14 months, and in level III-1 and level III-3 of 16 months were significant ($\chi^2 = 3$, $P < .05$; $\chi^2 = 3$, $P < .05$; $\chi^2 = 3.6$, $P < .05$; $\chi^2 = 6$, $P < .01$) The percent of children showing level III-1 at 12 months and level III-3 at 14 and 16 months increased and that of level III-1 at 16 months decreased on trial 2.

In other words, the preceding experience in a session influenced succeeding visual search in a different manner: decrement of level I and increment of level III-1 at 12 months, increment of level III-3 at 14 months, and decrement of level III-1 and increment of level III-3 at 16 months.

DISCUSSION

1. Development of Anticipatory Visual Search

The developmental change from level I to level III and 14 months as the transition period were shown. Within level III, the sequence was from level III-1 to level III-3 and the transition period was 22 months. As far as level II and level III-2 are concerned, they were never dominant. Level II, however, tended to decrease at 22 months and was not exhibited at 24 months. Moreover, when the object reemerged, the visual fixation to the tunnel entrance was still found in about half instances of level II whereas the behavior was seen in the majority of level I. On the other hand, level III-2 significantly increased at 22 months.

Therefore, level II and level III-2 are regarded as transitional levels in spite of their restricted occurrence.

Since the majority children demonstrated level III, most of which were level III-1, at 16 months and level III-3 at 24 months, the onset of definite and most definite anticipation is 16 months and 24 months, respectively, under the condition of no experience immediately before. Gratch (1982) revealed most 16-month-olds showed surprise responses on the trick trials where the different object reappeared. Since the surprise is considered as the reflection of infants' expecting the same object to reemerge, his findings support the results of this study. Because smile is interpreted as the reflection of tension-release or joy of mastery (Kagan, 1971; Sroufe & Waters, 1976), the data of children's smile and laughter to the experimenter are also supporter to the onset of definite and most definite anticipation. The onset of such behavior after the reappearance of the object was 16 months of age and that during the occlusion of the object was 24 months. Ramsey & Campos (1978) reported longer and earlier smile of the infants at stage 6 than those at stage 5 in manual search tasks.

Most responses of level I were the search of looking at the tunnel entrance and then the experimenter, and looking back to the entrance. The above search is considered as no use of temporal information despite the use of spatial information. The use of temporal information is not enough yet at level II and in the majority responses of level III-1 since the children often looked back to the entrance. The coordination of both spatial and temporal information is seen in the minority responses of level III-1 and at level III-2. The pursuit towards invisible movement of the object is accountable for such coordination. Level III is likely the most effective response of such coordination. The coordination of both spatial and temporal information was also seen in most 18-month-olds of the study by Haake & Somerville (1985). Therefore, the development of anticipatory visual search in this study suggests the process of coordination between spatial and temporal information in object permanence.

2. Effects of Preceding Experience upon Search

The preceding experience affected the subsequent visual search in a

different manner: decrease of level I and increase of level III-1 at 12 months, increase of level III-3 at 14 months, and decrease of level III-1 and increase of level III-3 at 16 months.

The similar tendency of different effects of the preceding experience upon consecutive behavior was also revealed in the studies on pretend play of this age level. In those studies, the effects of modeling were varied based on the age of children, which indicated children imitated the behavior that they could understand and control rather than blindly imitated (Fein, 1975; Fenson, 1984; Fenson & Ramsey, 1981; Largo & Howard, 1979; Watson & Fischer, 1977). Thus the different effects of the preceding experience per se are regarded as the reflection of children's development.

SUMMARY

The purpose of this study was to longitudinally examine the development of anticipatory visual search and to find out the effects of the preceding experience upon the subsequent search during the second year of life.

The subjects were 18 Japanese nonretarded children and were individually tested at 11, 12, 14, 16, 22 and 24 months. The child was once a month provided 2 trials for the task where the object disappeared at the tunnel entrance and reappeared at the exit. The child's visual fixation towards the object and the entrance, the exit and other zones of the tunnel was measured as well as the whole procedure being videotaped. The visual search during occlusion of the object was assigned to 5 levels of anticipation (see Table 1).

The developmental sequence from level I to level III and 14 months as the transition period were obtained. Within level III, the change was from level III-1 to level III-3 and the transition period was 22 months. Level II and level III-2 were regarded as transitional levels despite their limited emergence due to the decrement of their occurrence at later months. The above development was interpreted as the reflection of the process of coordination between spatial and temporal information in object permanence. The preceding experience affected the subsequent visual

search in a different manner. The different effects per se were considered as the reflection of children's development.

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Table 1 Definitions of Levels of Anticipatory Visual Search during Occlusion of Object

Level I	The child does not look at the tunnel exit.
Level II	The child looks at the tunnel exit but does not see the object reappear.
Level III	The child looks at the tunnel exit and see the object reappear.
	1. The child looks back to the tunnel entrance, other zones of the tunnel, or in combination besides looking at the tunnel exit.
	2. The child looks at other zones of the tunnel and the tunnel exit in order.
	3. The child immediately looks at the tunnel exit and waits for the object to reappear.

Note: Looking at the experimenter is included at all levels.

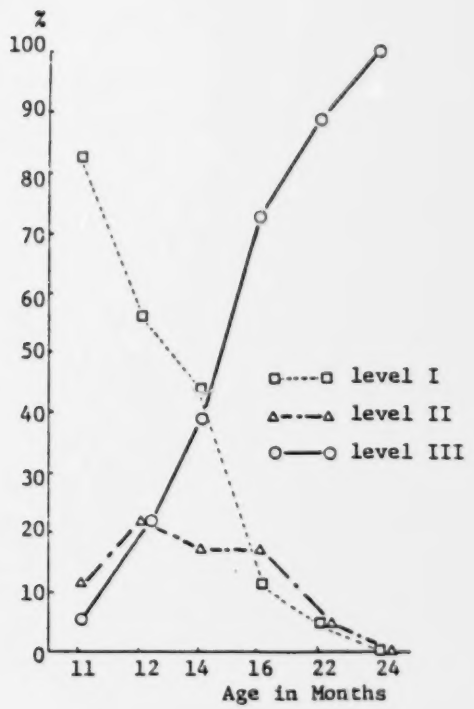

Fig. 1 Percent of Children Showing Each Level on Trial 1

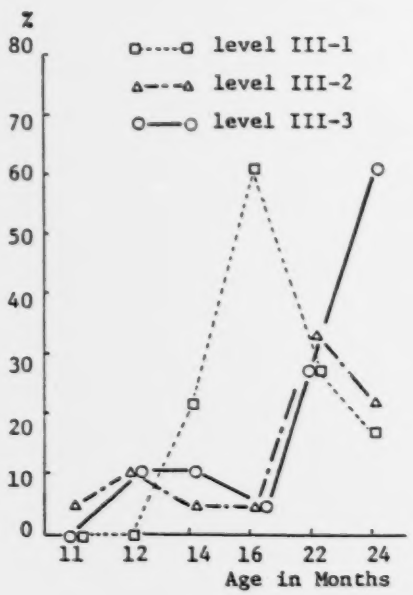

Fig. 2 Percent of Children Showing Each Sublevel of Level III on Trial 1

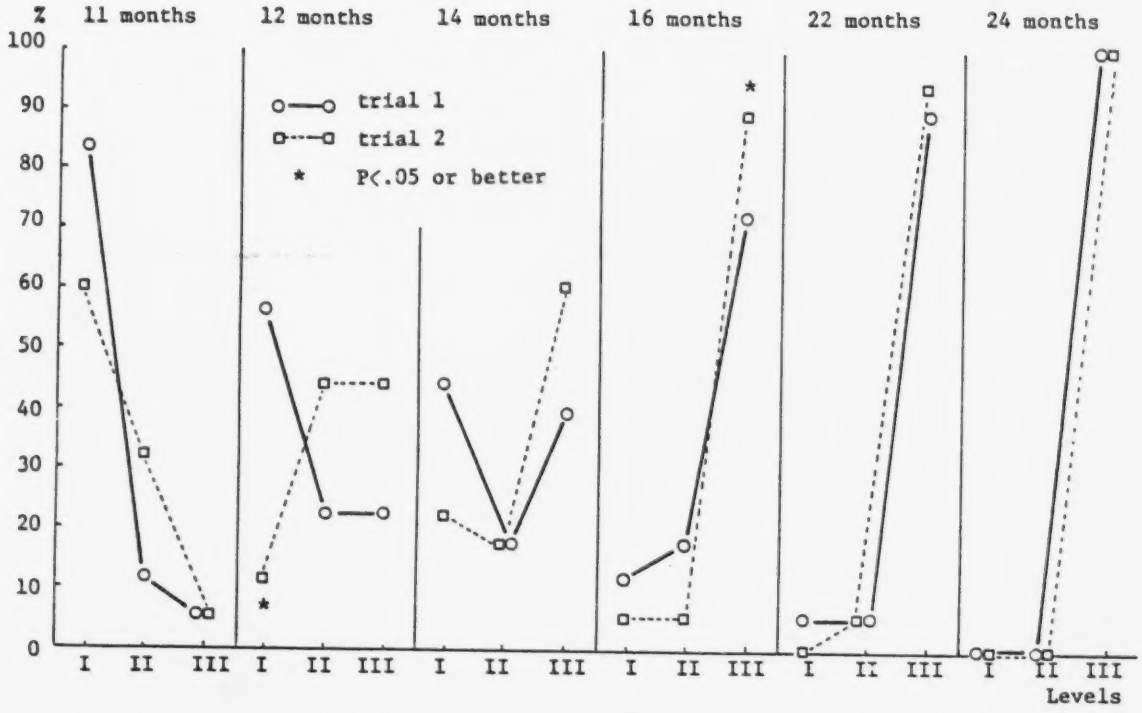

Fig. 3 Percent of Children Showing Each Level at Each Month of Age

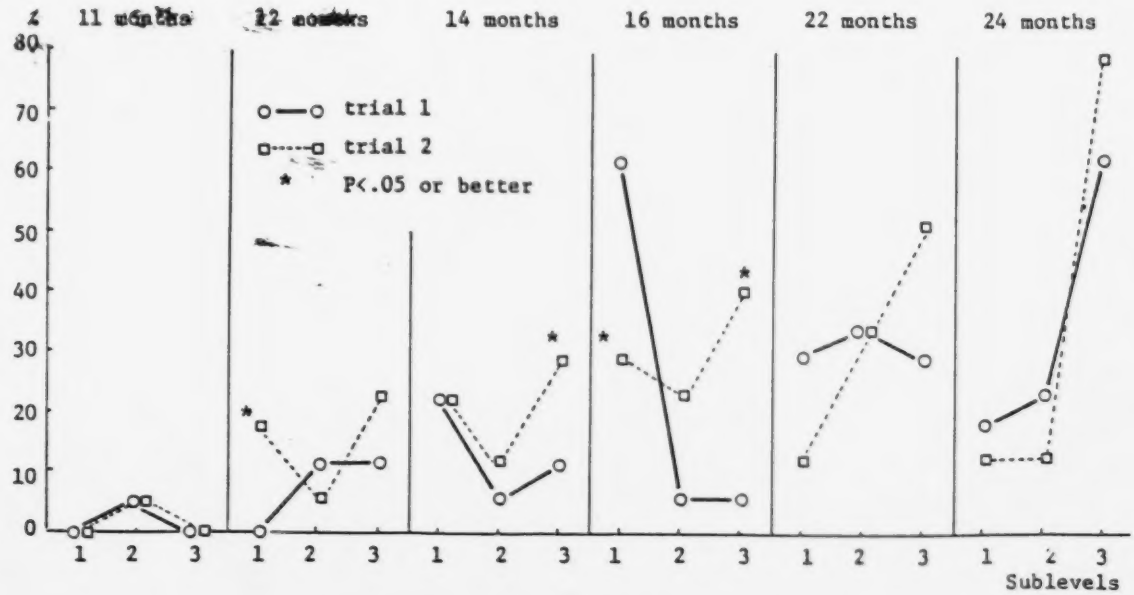

Fig. 4 Percent of Children Showing Each Sublevel of Level III at Each Month of Age

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